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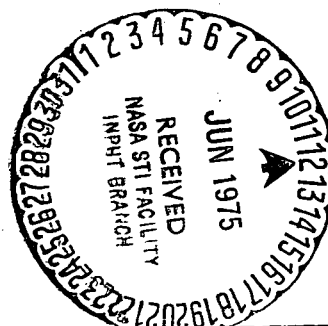
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## SPACE AND NUCLEAR

## RESEARCH AND TECHNOLOGY

## SPACE AND NUCLEAR RESEARCH AND TECHNOLOGY

The Space and Nuclear Research and Technology Program, under the Office of Aeronautics and Space Technology, provides the technology base for space activities. This includes use of the Space Shuttle-Spacelab opportunity to conduct innovative research and technology programs in the space environment.

The program advances the engineering sciences and technologies needed to transport, power and control spacecraft, and to improve the scientific instruments needed for NASA space missions.

The space and nuclear research and technology program consists of a research and technology base, system studies, system technology programs, entry systems technology and experimental programs.

### Research and Technology Base (R&T)

The R&T base provides fundamental knowledge and understanding in the space scientific and engineering disciplines and applies this knowledge to establish the feasibility of a concept or new techniques and design data.

These studies include materials, structures, fundamental electronics, space guidance and control, information systems, chemical propulsion, electric propulsion, space energy systems, nuclear energy, high power lasers and entry technology.

Materials. Materials are sought for advanced spacecraft and propulsion systems to withstand the rigors of space for long periods of time. Examples include:

- Basic research to increase understanding of the behavior of materials to improve their properties and efficiencies.
- Advanced structural materials, bearings, seals, and lubricants for future space vehicles and their propulsion and power systems.
- Defining and providing materials technology for thermal protection systems, thermal control and environmental protection applicable to the Space Shuttle, planetary probes and advanced Earth orbital spacecraft.

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Structures. The objective is to develop advanced structures technology for space systems emphasizing new design concepts and methods, composite structures, dynamic loading and response, and pressure vessel design. Examples include:

- Evaluating potential applications of composites for flight-weight pressure vessels.
- Evaluating and demonstrating concepts for large folding antennas and other large folding structures.
- Providing efficient analytical and experimental techniques for low-cost confirmation of the adequacy of space structures for dynamic loading conditions.
- Achieving better understanding of fractures in spacecraft components, such as pressure vessels, through studies of fracture mechanics and environmental effects.
- Continued evaluation of thermal protection system structural panels, investigation of Shuttle dynamics response with scaled models, and development of the NASA Structural Analysis Computer Program analysis methods applicable to the Shuttle and other vehicle requirements.

Fundamental Electronics. Theoretical studies and experimental investigations were used to develop the basic technology in advanced electro-optic concepts, electronic devices, and long-life circuit arrays needed to design and synthesize efficient electronic systems. Examples include:

- Active and passive optical techniques for measuring pollution, Earth resources, and planetary features.
- Electronic concepts and components for detection, measurement, storage, and display of information which are smaller, lighter, more efficient, and more economical than currently available technology.
- Methods to obtain minimum failure rates and consistently high quality integrated circuit arrays with reliable operating lives of five to six years.

Space Guidance and Control. The objective is to provide the technology to control and maneuver manned and unmanned aerospace vehicles in the exploration and exploitation of space at minimum costs while maintaining and improving performance standards. Examples include:

- Low cost guidance and control components and concepts to reduce production costs by 50 per cent or more.
- Advanced navigation techniques to increase trajectory determination accuracy by a factor of 10.
- Approach guidance technology for planetary missions to minimize fuel usage and permit payload increases up to 50 per cent.
- Problem solving software and hardware, and techniques for integrating sensors and controls to permit operation of unmanned vehicles or robot machines.

Information Systems. The objective is to provide components and techniques for processing, transmission, and reduction of data from future planetary, applications and data transfer satellites. Examples include:

- Developing techniques to increase the speed of calculation, storage capacity, and reliable operating life of spacecraft computer-based data processing systems.
- New designs for longer life, improved performance spacecraft radio systems, and components for multi-mission applications.
- Advancing laser technology to permit high rate data transfer from Earth observation satellites and to allow precise determination of satellite position for geophysical measurements.

Chemical Propulsion. The objective is to provide the research and technology base for the development of chemical propulsion systems for NASA's future mission requirements that meet the continuing need for cost reduction in propulsion, for high performance systems suitable for long duration planetary missions, and in compliance with atmospheric pollution standards. Examples include:

- Reusable cryogenic propulsion systems -- establish the technology of high performance reusable oxygen/hydrogen propulsion systems demonstrating 10-hour service life over 20 missions.
- Long-life liquid propulsion systems -- establish high-energy propellants, materials, components and engines with 10-year life capability.
- Low-cost propulsion systems -- development of new capabilities in solid and liquid propulsion to allow reductions in mission cost.
- Chemical propulsion physics and chemistry -- increase performance life, reliability and stability of chemical propulsion systems through a better understanding of chemical and physical processes and materials. Also, the establishment of new propellants and propulsion concepts yielding 100 per cent increase in specific impulse.
- Atmospheric effects -- determining the effects of rocket exhausts on the atmosphere by establishing species concentrations in the troposphere and stratosphere through investigation of reactions between exhaust products and atmosphere.

Electric Propulsion. The objective in electric propulsion is to provide the technology for high specific impulse electric propulsion systems needed for advanced capabilities in near-Earth and planetary/interplanetary applications. Examples include:

- Exploring the full potential of electric propulsion and doing basic research to extend reliability and life of electric propulsion systems.

- Auxiliary electric propulsion systems -- establish technology of long-life, reliable electric propulsion systems for station-keeping and altitude control applications.
- Primary electric propulsion thruster/power module -- establish technology of long-life, high performance ion thruster/power processor module.
- Primary solar electric propulsion systems -- demonstrate technology of a modular ion thruster system for 3-20 kw range and evaluate S/C interactions.

Space Energy Systems. The objective is to provide the research and technology base for development of space power systems for NASA's future mission requirements. Research and technology will emphasize major increases in performance (two to 10 times current levels) and reduction (50 per cent or more) in system costs. Examples include:

- Solar cells/arrays -- achieve cost reductions through advanced production techniques while doubling radiation resistance and increasing power density by 50 per cent.
- Chemical energy conservation and storage -- achieve a doubling of the energy density and life of batteries. Achieve cost reductions by 90 per cent while increasing stack life of 10,000 hours for fuel cells.
- Power processing -- achieve an increase in the power level by a factor of 10 and increase life to 10-20 years.
- Thermomechanical conversion -- achieve the technology of high efficiency thermomechanical conversion systems for space and terrestrial uses, with emphasis on extending the power of isotope space power systems to 0.5 - 2.0 KWe at one-fourth the cost of isotope thermoelectric systems.

Nuclear Energy. The objective is to conduct research and provide technology for the application of nuclear energy to propulsion and the generation of power in space, thereby providing a base of relevant technology for future decisions regarding advanced missions.

The program includes:

- Gaseous fueled reactor research -- achieve nuclear power from a fissioning gas or plasma at temperatures ranging from near room temperature to 10,000 K and at power levels from a few kilowatts to thousands of megawatts, with the potential for advances in fuel breeding and waste product processing.
- Thermionic power conversion systems -- achieve efficient and, under space conditions, reliable conversion of heat into electricity at minimum system weight and maintenance requirements, through expanding the previously gained knowledge of thermionic devices to that of low temperature operation.
- Space thermoelectric systems -- provide the technology to achieve effective use of nuclear radioisotope thermoelectric generator systems in spacecraft.

High Power Lasers and Energetics. The objective is to conduct basic research with new data and physics principles for improved capabilities in the generation, transmission, and conversion of power in space and on Earth, including the conversion of power into thrust and other useful forms of energy. Examples include:

- Fusion and plasma dynamics research -- continued research on fusion plasmas for evaluating the possibilities of future utilization of fusion energy in space and on principles of magnetohydrodynamic power conversions.
- Magnetism and cryophysics research -- application of superconductivity and high magnetic fields in basic physics studies, power generation and conversion, and energy storage.
- Photonics -- determine basic data on molecular, atomic, and nuclear reaction cross sections, reaction rates and electromagnetic radiation and absorption spectra in plasmas and gases for applications in propulsion, power, lasers and space and atmospheric physics.



- High power laser systems -- determine potential for transmitting energy over great distances in space to provide major cost reductions in space power and propulsion. (Fission energy from a nuclear reactor was successfully converted directly into laser light for the first time in September 1974.)

Entry Technology. The endeavor here is to provide an understanding of entry aerodynamic and heat transfer problems of spacecraft for Earth orbital missions and planetary exploration and to develop aerothermodynamic technology for improved spacecraft design, safety and reliability. Examples include:

- Space Shuttle development support -- provide aerothermodynamic support for the Space Shuttle design, development and verification through analysis and solution of problem areas and utilization of wind tunnel facilities.
- Planetary probe technology -- provide the aerothermodynamic technology base required for the design of exploratory probes into the atmospheres of Venus, Uranus, Saturn and Jupiter.
- Advanced Earth orbital transportation technology -- establish aerothermodynamic technology for design of future spacecraft for the 1990s and beyond with emphasis on reusable single and two stage-to-orbit vehicles capable of vertical or horizontal take-off.

### Systems Studies

The objective of system studies is to identify areas for future technology focus, including continuous examination of current technology objectives to ensure their appropriateness and payoff, and to provide the necessary technical and economic decision base to support the selection of future system technology programs and experimental programs. The program objective is accomplished through studies in each of the general areas of space science, applications, manned space flight and space transportation. Particular emphasis is placed on studies to:

- Define criteria and resulting requirements for technology readiness of planned and projected future missions. Define associated technology development program plans.

- Evaluate the effects of incorporating planned technology advances or available technology alternatives on planned, projected and optional future missions.
- Establish, for future missions, parametric tradeoffs and sensitivities relating the level of technology in critical disciplines to various measures of flight program accomplishments -- e.g., performance, cost, benefits, etc.
- Recommend individual and integrated technology program goals on the basis of analysis such as those indicated above.

### System Technology Programs

The objective of System Technology Programs is to apply the fundamental knowledge gained in the R&T base to the development of innovative system technology and to demonstrate the technical readiness of innovative systems through experimental testing and verification in a realistic environment.

Guidance Control and Information System Technology. The objective is to design, develop and demonstrate feasibility and technical acceptability of advanced guidance control and information system concepts, to establish user confidence in systems capabilities and promote application of systems which improve performance and reliability of space missions. For example:

- Provide a modular, no-moving part,  $10^8$  bit, data storage system using magnetic bubble domain technology and demonstrate the performance versatility and improved reliability of the system in tape recorder applications. In the first phase of this program, a  $10^8$  bit solid state data storage system will be designed, basic memory elements fabricated and an engineering breadboard system constructed and tested. In the succeeding phase, a fully populated  $10^8$  bit, prototype data storage system will be constructed and qualified to flight standards to demonstrate technology readiness.

Entry Systems Technology. The objective is to investigate the piloting problems, performance, and handling qualities of the joint NASA/USAF X-24B lifting body vehicle over a range from low supersonic speeds to landing. The purpose of these studies is:

- To provide experimental flight data for validation of wind tunnel prediction capability.
- To establish a technological data base for vehicle configurations which will be useful to advance Earth orbital vehicle design and military aircraft.
- To provide additional experience with approach and landing techniques useful to Space Shuttle operations.

#### Experimental Programs

The objective of the space experimental programs is to design, fabricate and test multidisciplinary advanced technology experiments in the space environment, thereby reducing the technical risk in qualifying new technology for use on future missions. Included within the objective is the development of major research payloads for future missions.

Space Technology Shuttle Payloads. The Space Technology Shuttle Payloads Program defines and develops space laboratories which enable OAST and other research organizations to utilize in an economical manner, the capabilities of the ground based facilities by permitting research and technology investigations to be conducted in space. It also defines and develops technology experiments in specific discipline areas which utilize these facilities or the Shuttle and Spacelab directly.

The program currently consists of three elements: Shuttle Payload Definition, Long Duration Exposure Facility and Flight Experiments.

- The Shuttle Payload Definition -- conducts studies to determine the feasibility of Shuttle-Spacelab space technology facilities (such as the Advanced Technology Laboratory) or experiments; defines the objective, technical approach and resource requirements; and establishes the need, relevancy and timeliness of the effort. Studies are used to stimulate new initiatives so that the effort may culminate as a space facility or experiment.

- The Long Duration Exposure Facility -- develops and flies during the Orbiter Test Flight Program, a low-cost facility which utilizes the Shuttle capabilities and which provides the means to perform a large number of essentially passive exposure type experiments in space. It broadens the Shuttle user community for subsequent Long Duration Exposure Facility and other Shuttle flights.
- Flight experiments -- design, fabricate and fly specific technology experiments on Shuttle missions, such as the Long Duration Exposure Facility, the Advanced Technology Laboratory, and the joint NASA-ESRO Spacelab mission. Flight experiments are defined, approved as Shuttle or Spacelab experiments (though not necessarily assigned to specific missions), and are funded through the completion of a specific experimental objective including data analysis.

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